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Investigating the alternative-sensitivity of *know* *

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Abstract Several semantic analyses of *know* have been proposed in recent years to account for the so-called Gettier Problem. These analyses make distinct predictions regarding the sensitivity of *know* to the alternative possibilities expressed by its complement, as induced by expressions such as disjunction. These predictions were tested in two experiments. Results show that knowledge sentences with a disjunctive complement (e.g., *John knows that Mary has a son or a daughter*) are more likely to be judged as false than classically-equivalent sentences with non-disjunctive complements (e.g., *John knows that Mary has a child*) under Gettier-like scenarios. We discuss how these findings provide evidence for the alternative-sensitive approach to *know*.

Keywords: *know*, Gettier problem, alternative-sensitivity, disjunction, experiment.

1 Introduction

The notion of alternatives plays an important role in a variety of areas in natural language semantics. In particular, work in Alternative Semantics (e.g., Kratzer & Shimoyama 2002; Alonso-Ovalle 2006) and Inquisitive Semantics (e.g., Groenendijk & Roelofsen 2009; AnderBois 2011) has focused on specific expressions, such as disjunctions, indefinites and *wh*-expressions, that introduce alternatives in semantic representations. The interaction between these alternatives and alternative-sensitive operators enables explanations of a variety of semantic puzzles such as free-choice, disjunctive antecedents of counterfactuals, and the behavior of *wh*-indeterminates.

This paper presents yet another case in which alternatives introduced by a disjunction interact with an alternative-sensitive operator. Following Uegaki (2012), we analyze the verb *know* as an alternative-sensitive expression, and derive the falsity of the sentence *x knows that S* in the so-called Gettier cases (Gettier 1963) in

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terms of the alternative-sensitivity. This analysis makes distinct predictions from Kratzer's (2002) semantic analysis of Gettier cases. Specifically, the alternative-based analysis predicts that a knowledge sentence with a disjunctive complement can have a different truth value from one with a non-disjunctive complement, even when the complements of the two sentences are classically equivalent. This prediction was tested in a series of experiments using a truth value judgment paradigm. We discuss how the results favor the alternative-based analysis.

2 The Gettier Problem and two existing semantic analyses

Gettier cases are well-known counterexamples to the traditional view that the possession of a justified true belief constitutes knowledge (Gettier 1963). Consider for instance the Gettier scenario in (1a). The knowledge attribution in (1b) is intuitively false, although the proposition 'Jones owns a Ford or a BMW' is a true and justified belief of Smith.

(1) a. Smith justifiably believes that Jones owns a Ford (He saw Jones with the key of a Ford, driving a Ford etc.). He justifiably deduces from this belief that Jones owns a Ford or a BMW although he is unopinionated about whether Jones owns a BMW. However, it turns out that Jones in fact does not own a Ford although he owns a BMW.

b. # Smith knows that [Jones owns a Ford or a BMW].

Gettier cases present a challenge to the semantics of the verb *know* because the simple-minded analysis in (2), which treats *know* as *justifiably believe* + factivity presupposition, inaccurately predicts the sentence in (1b) to be true, as shown in (2b).

(2) a. $[\![\text{know}]\!]^w = \lambda p : [p(w) = 1] \lambda x.\ \mathsf{JBel}(x, p, w)$
(where $\mathsf{JBel}(x, p, w)$ iff x justifiably believes p in w)

b. $[\![(1b)]\!]^w = 1$ iff [Jones owns a Ford or a BMW in w]
& $\mathsf{JBel}(S, \lambda w'.$Jones owns a Ford or a BMW in $w', w)$

One could argue that this is not a problem that has to be dealt with in the semantics of natural language, but rather a problem in epistemology, to which the semantics can refer. That is, semanticists can refer to a primitive constant in the metalanguage to define the denotation of the verb *know*, and the analysis of the nature of this constant can be left to philosophers. The Gettier problem might be one of the problems about the nature of this constant, and linguists might not have to deal with it.

However, if the problem is shown to have an interesting connection to other linguistic problems, it is worthwhile to investigate whether the problem can be

approached in terms of the semantic theories that have been proposed to deal with them. This is the kind of motivation that is behind Kratzer's (2002) situation-semantic analysis, in which she uses the notion of EXEMPLIFICATION or MINIMALITY of situations to account for both Gettier cases and counterfactuals. Uegaki (2012) proposes an analysis of Gettier cases which makes crucial use of the notion of ALTERNATIVES, following other authors that have used the same notion to account for a variety of linguistic phenomena, such as focus-related constructions (Dretske 1972; Rooth 1985), questions (Hamblin 1973; Groenendijk & Roelofsen 2009), and free-choice disjunction (Kratzer & Shimoyama 2002; Alonso-Ovalle 2006). Below, we review Uegaki's (2012) alternative-based analysis and Kratzer's (2002) situation-semantic analysis in order.

2.1 Alternative-based analysis

Uegaki (2012) proposes to account for the Gettier problem by treating *know* as sensitive to the alternative propositions of the complement. In this analysis, the traditional 'truth', 'belief' and 'justification' conditions are stated in terms of an existential claim of a proposition in the set of alternatives for the complement. Further, there is an additional condition for this proposition to be the strongest among the alternatives that the subject justifiably believes.[1,2] This is formulated as follows:[3]

1 The intuition behind this analysis goes back to one of the earliest responses to the Gettier problem: the No-False-Premise theory (e.g., Clark 1963). The theory states that knowledge must not be based on an inference from a false premise. The theory correctly predicts that the true belief in the Gettier cases is not an instance of knowledge since they are based on a false premise. In the case of (1a), the false premise corresponds to the belief that Jones owns a Ford. In Uegaki's (2012) analysis of the verb *know*, the notion of premise in the No-False-Premise theory corresponds to the notion of alternatives. See Lycan 2006 for a recent argument for the No-False-Premise theory as an analysis of the core Gettier cases, and his replies to the existing counterarguments.

2 In the literature in epistemology, some researchers have discussed a class of putative Gettier cases that cannot be correctly analyzed this way. One paradigm case of this class is the 'fake barn' case by Goldman (1976). We think that such cases are crucially different from the standard Gettier cases exemplified in (1) in that they involve skeptical information that is independent of the subject's belief state.

As Kratzer (2002) notes, a knowledge sentence in the fake barn case is judged less clearly as false if the skepticism in the context is weaker (e.g., only a few of the barns are fake). In contrast, the judgment of the falsity in the standard Gettier cases is not affected by contextual factors which are external to the subject's belief state. Thus, we claim that these other Gettier cases should be treated separately from the standard cases discussed in the previous section. More specifically, we assume that the skeptical information in the context of these cases raises the standard of belief *justification*, along the lines of Epistemic Contextualism (cf. e.g., DeRose 1992).

3 In the formulae hereafter, some variables are used to stand either for an English expression or for its metalanguage translation depending on the context (i.e., whether it is inside ⟦ ⟧ or not) for expository

(3) $[\![x \text{ knows } S]\!]^{w,E}$ is defined if $[\![\text{S}]\!]^{w,E} = 1$ and if defined, is 1 iff

$$\exists p \in [\![\text{S}]\!]_{Alt} \left[\begin{array}{ll} \text{(i)} & p(w) = 1 \wedge \\ \text{(ii)} & \mathsf{JBel}(x,p,w,E) \wedge \\ \text{(iii)} & \neg\exists p' \in [\![S]\!]_{Alt}[p' \subset p \wedge \mathsf{JBel}(x,p,w,E)] \end{array} \right]$$

(where $\mathsf{JBel}(x,p,w,E)$ iff x justifiably believes p based on evidence E)

The additional condition in (iii) correctly predicts (1b) to be false in the Gettier scenario in (1a), assuming that the alternative propositions of the complement include the propositions which correspond to individual disjuncts of the complement as well as the complement itself, as shown in (4).[4]

(4) $[\![\text{Jones owns a Ford or a BMW}]\!]_{Alt} = \{F \vee B, F, B\}$
where $F = \lambda w.$ Jones owns a Ford in w; $B = \lambda w.$ Jones owns a BMW in w

The truth conditions correctly predict that (1b) is false in the Gettier scenario in (1a). This is so because there is no proposition in the alternatives given in (4) that satisfies the three conditions in (3): F does not satisfy (i), B does not satisfy (ii), and $F \vee B$ does not satisfy (iii). The reason why $F \vee B$ does not satisfy (iii) is that the attitude holder Smith believes F which is stronger than $F \vee B$.

There is an additional detail in the above account that needs a further explanation. The truth conditions in (3) are relativized to a particular piece of evidence E based on which the agent x believes the relevant propositions. (In (3), JBel is defined as a four-place predicate which includes the 'evidence' argument.) This is to make sure that the third condition in (3) deals with the agent's beliefs based on which the relevant knowledge is inferred or justified. For an illustration of why this additional detail is needed, consider the following example:

(5) a. Smith has heard from Jones' sister that he owns either a Ford or a BMW, but she does not remember which. Jones' sister is a reliable person and Smith has no reason to doubt her. Another day, Smith saw Jones driving a Ford, so he concluded that Jones owns a Ford. However, Jones in fact does not own a Ford although he owns a BMW.

b. Smith knows that Jones owns a Ford or a BMW.

What is different between (5) and (1) is that there is an additional piece of evidence in (5) which suggests that Jones owns a Ford or a BMW, i.e., the report

purposes. For example, the variable x in the left-hand side of (3) stands for an English expression in the subject position of *know* while that in the right-hand side stands for the individual denoted by such an expression.

4 The inclusion of these propositions in the set of alternatives comes about both in Alternative Semantics (e.g., Alonso-Ovalle 2006) / Inquisitive Semantics (e.g., Groenendijk & Roelofsen 2009) or structure-based theories of alternatives (e.g., Katzir 2007; Fox & Katzir 2011).

from his sister. Some native speakers find the knowledge attribution in (5b) to be true by virtue of this additional piece of evidence (Results from our experimental investigations will be shown in the next section). The formulation in (3) enables us to understand the availability of this judgment in the following way. In (5a), there are two independent pieces of evidence based on which Smith can infer the belief that Jones owns a Ford or a BMW, which can be described as follows:

(6) E_1: Jones' sister told Smith that Jones owns either a Ford or a BMW.
E_2: Jones was driving a Ford.

If we evaluate (5b) relative to just E_1, then we predict it to be true since Smith does not believe F *based on just* E_1, and so the proposition $F \vee B$ (which he believes based on just E_1) would satisfy the third condition in addition to the first two conditions. On the other hand, if we evaluate (5b) relative to $E_1 + E_2$ i.e., the full set of evidence available in the context, then we predict falsity since the alternative F is believed by Smith based on $E_1 + E_2$, and thus $F \vee B$ fails the third condition.

2.2 Situation-semantic analysis

The second type of approach to the Gettier problem does not treat *know* as alternative-sensitive. An example is Kratzer's (2002) situation-semantic analysis:

(7) a. $[\![x \text{ knows that } p]\!](s*) = 1$ iff there is a situation s that *exemplifies* p such that (i) $s \leq s*$, (ii) x believes p in $s*$ *de re* of s, and (iii) all relevant possible worlds in which the subject has the same subjective experience as they do in $s*$ have counterparts of s where p is true.

b. A situation s EXEMPLIFIES a proposition p iff $p(s) = 1$ and (i) for all $s' < s$, $p(s') = 0$ (i.e., s is a minimal situation making p true) or (ii) for all $s' < s$, $p(s') = 1$.

According to this analysis, *x knows that p* is true iff x is in a particular relationship to a 'minimal' fact s which makes p true so that x believes p *de re* of s. In the Gettier case in (1), the minimal fact making the complement true is the minimal situation involving Jones, the BMW, and the owning relationship holding between them. Let's call this minimal situation s_B. A necessary condition for an individual x's believing p *de re* of s is that for any doxastic alternative world w of x, a counterpart of s is true in w. Given this assumption, we see that Smith in (1) does not believe the complement *de re* of s_B since a counterpart of s_B is not true for some of his doxastic alternatives in the Gettier scenario. Thus, this situation-semantic analysis correctly accounts for the truth-value judgment of the Gettier case in (1).

2.3 The predictions of the two analyses

Both of the two semantic approaches to the Gettier problem summarized in the previous sections make the correct prediction for the Gettier case we started with. However, when applied to new cases, these approaches make distinct predictions based on their assumptions about the alternative propositions. In this section, we discuss these distinct predictions in an abstract setting. Then, in the next sections, we discuss the results of two experiments that tested these predictions using concrete examples.

As we discussed earlier, the crucial difference between the two approaches lies in whether the truth conditions of sentences of the form *x knows that S* depend on the alternative-semantic value of *S*. This difference results in distinct predictions when we consider the following case. Suppose that there are sentences S and S' whose ordinary- or situation-semantic value and the alternative-semantic value look like the following:

(8) a. $[\![S]\!] = [\![S']\!]$
b. $[\![S]\!]_{Alt} = \{p, q\}$, $[\![S']\!]_{Alt} = \{r\}$

Furthermore, suppose that John's belief state and the fact in the actual world w are as follows:

(9)

	p	q	r
John's belief on E	Yes	No	Yes
Fact in w	No	Yes	Yes

Given these assumptions, we see that the alternative-based analysis predicts that the truth values of *x knows S* and *x knows* S' in w differ, whereas the situation-semantic analysis predicts that they don't. More specifically, the two analyses yield the following two predictions.

(10) **Alternative-based analysis**
$[\![\text{John knows } S]\!]^{w,E} = 0$; $[\![\text{John knows } S']\!]^{w,E} = 1$

(11) **Situation-semantic analysis**
$[\![\text{John knows } S]\!]^{w} = [\![\text{John knows } S']\!]^{w}$

The first half of (10) derives from the fact that neither p nor q satisfies the condition that it is one of John's strongest true beliefs, whose existence is necessary for the sentence to be true according to the alternative-based analysis. By contrast, the second half of (10) is due to the fact that the proposition r is John's strongest true belief in the alternatives for S', which is the singleton set of r. On the other hand, as stated in (11), the situation-semantic analysis does not predict this kind of discrepancy in truth values between *John knows that S* and *John knows that*

S'. The analysis does not make reference to the alternative-semantic value of the complement, and since the situation-semantic values of S and S' are equivalent by assumption, there should be no difference in meaning between *John knows that S* and *John knows that S'*.

What then would be the concrete examples of S and S' in the above case? It depends on the assumptions about alternative-semantic values. Here, following the literature in alternative semantics and inquisitive semantics (e.g., Kratzer & Shimoyama 2002; Alonso-Ovalle 2006; Groenendijk & Roelofsen 2009), we adopt the following assumptions:

(12)
- A disjunction introduces alternatives corresponding to the ordinary semantic value of its disjuncts:
  $[\![\text{S}_1 \text{ or } \text{S}_2]\!]_{Alt} = [\![\text{S}_1]\!]_{Alt} \cup [\![\text{S}_2]\!]_{Alt} \cup \{[\![\text{S}_1]\!], [\![\text{S}_2]\!], [\![\text{S}_1 \text{ or } \text{S}_2]\!]\}$
- An indefinite introduces alternatives corresponding to the individuals in the extension of the NP it combines with:
  $[\![\text{a NP}]\!]^w_{Alt} = \{\lambda P.P(x) \mid x \in [\![\text{NP}]\!]^w\} \cup \{[\![\text{a NP}]\!]^w\}$

Given these assumptions about alternatives, we see that the following sentences in (13) can be the concrete examples of S and S' considered in the above discussion.

(13) S: Mary has a son or a daughter.

S': Mary has a child.

The two sentences (13S) and (13S') are equivalent in the ordinary semantic dimension, but have different alternative semantic values as shown below.[5]

(14) a. $[\![S]\!] = [\![S']\!] = p_c$

b. $[\![S]\!]_{Alt} = \{p \mid \exists x[x \in [\![\text{son or daughter}]\!]^w \wedge p = \lambda w.\text{Mary has } x]\} \cup \{p_s, p_d, p_c\}$

c. $[\![S']\!]_{Alt} = \{p \mid \exists x[x \in [\![\text{child}]\!]^w \wedge p = \lambda w.\text{Mary has } x]\} \cup \{p_c\}$

- $p_s = \lambda w.$ Mary has a son in w
- $p_d = \lambda w.$ Mary has a daughter in w
- $p_c = \lambda w.$ Mary has a son or a daughter in $w = \lambda w.$ Mary has a child in w

5 A similar kind of contrast between disjunctive and non-disjunctive sentences is predicted in the 'structural alternatives' view proposed by Katzir 2007 and Fox & Katzir 2011 if we modify the theory so that alternatives derived by *contraction* have priority over those derived by *replacement* of some sub-constituent. In this version of the structural alternatives theory, 'Mary has a son' is in the set of 'privileged' alternatives for the disjunction 'Mary has a son or a daughter' since it can be derived by contraction. On the other hand, the same alternative can be derived from 'Mary has a child' only by replacing the NP, and thus it cannot serve as an alternative for 'Mary has a child' in the same status as it is for 'Mary has a son or a daughter'.

Consider a scenario where John believes p_s, but does not have a belief about p_d nor any p of the form 'Mary has specific child x', and where Mary in fact has a daughter, but no son. Given this scenario, the alternative semantic analysis predicts *John knows S* to be false, but *John knows S′* to be true (for the same reasons as in the above abstract examples). In $[\![S]\!]_{Alt}$, we cannot find a true proposition which is one of John's strongest beliefs. The proposition p_c is indeed true and believed by John, but p_s is stronger than p_c. On the other hand, in $[\![S']\!]_{Alt}$, p_c is both true and the strongest proposition believed by John. We tested this prediction using similar kinds of examples in a series of experiments, to which we now turn.

3 Experiment 1

3.1 Participants

101 self-identified native speakers of English (49 female, aged 21-67, mean = 32 yrs, standard deviation = 11 yrs), all located in the United States, were recruited using Amazon Mechanical Turk. Education levels ranged from some High School to Graduate Study; 75% selected either 'Bachelors degree' or 'Graduate degree'. Participants were compensated for their time. To screen out repeat participants, we asked people to take this experiment only once, and informed them that they would not be paid for retakes. Submitted data from participants with identical Worker IDs and/or IP addresses were systematically excluded.

3.2 Materials and Methods

Participants were presented with short scenarios, as exemplified in (15). Each scenario ended with a statement of facts that turns it into either a Gettier-Like (15a) or a Non-Gettier (15b) scenario (see Appendix).

(15) **Example story:** John is the coach of a little league baseball team. Today, John heard from Mary, one of his neighbors, that she wants her child to be on his team. John did not know that Mary had a child until then, but he is sure that her child is a boy since all of the kids on his team are boys, and girls rarely join a baseball team. He is not certain if Mary also has a daughter or not.

a. In fact, Mary has a daughter, but no son. (Gettier-Like)

b. In fact, Mary has a son, but no daughter. (Non-Gettier)

After reading each scenario, participants were asked to provide absolute truth-value judgments (i.e., 'True' or 'False') for two comprehension sentences and one target sentence. Comprehension sentences were unambiguous true or false sentences

designed to ensure that participants were attending to the relevant aspects of each scenario and in particular to the main characters' beliefs, as exemplified in (16).

(16) **Comprehension sentences**

a. John is sure that Mary's child is a boy.

b. John is sure that Mary has a daughter.

Target sentences were knowledge sentences whose embedded complements involved either a disjunctive (17a) or a non-disjunctive (17b) clause.

(17) **Target *know*-sentences**

a. John knows that Mary has a son or a daughter. (Disjunctive)

b. John knows that Mary has a child. (Non-disjunctive)

Four experimental conditions were obtained by crossing the two types of scenarios (Gettier-Like/Non-Gettier) with the two types of *know*-sentences (Disjunctive/Non-disjunctive). Four lists of test items were created using a Latin-Square design, so that each condition was instantiated by one item in each list.

In addition to test items, participants were presented with filler items. These items were included to disguise the purpose of the experiment, as well as to balance the number of expected 'True' and 'False' responses in the whole study. Filler items involved scenarios in the same spirit as those used in test items, but were followed only by comprehension sentences. Filler items were not considered for analysis.

3.3 Predictions

The predictions made by the Situation-semantic and the Alternative-sensitive views are given in Table 1. According to both views, Non-disjunctive sentences of (17b) are true in Non-Gettier and Gettier-like scenarios. This is so because the present Gettier-like scenarios were constructed so that the attitude-holder possesses a piece of evidence for believing the disjunctive proposition independently of her belief in a specific disjunct, unlike standard Gettier cases such as (1). However, both views differ regarding what responses to Disjunctive sentences of (17a) are acceptable in Gettier-Like scenarios.

The Situation-semantic view predicts Disjunctive sentences to be true under Gettier-Like scenarios, just as Non-disjunctive sentences. This is because, by assumption, the Situation-semantic analysis of *know* is only sensitive to the truth-conditional component of the complement, and the truth-conditions of the complements of Non-disjunctive and Disjunctive sentences (e.g., (17a) and (17b), re-

Condition	Gettier-Like	Disjunction	Predicted response	
			Sit-semantic	Alt-based
(a)	No	No	True	True
(b)	Yes	No	True	True
(c)	No	Yes	True	True
(d)	Yes	Yes	True	True/False

Table 1 Summary of the predictions made by the Situation-semantic (Sit-semantic) and the Alternative-sensitive (Alt-based) views as a function of experimental condition.

spectively) are equivalent. Thus, according to this analysis, participants' responses should not substantially differ across the four conditions.[6]

On the other hand, following the Alternative-sensitive view, Disjunctive sentences are predicted to be *ambiguous* under Gettier-Like scenarios: their truth-value depends on which piece of evidence is chosen as E in (3). For example, in the Gettier-Like scenario (15a), the sentence (17a) is false if E is the total piece of evidence available in the scenario (i.e., both E_1 and E_2 in (18) combined), but true if E is just the piece of evidence corresponding to Mary's mentioning of her child (i.e., only E_1). By contrast, Non-disjunctive sentences such as (17b) are predicted to be unambiguously true in Gettier-Like scenarios since their complements do not contain any relevant alternative-inducing expression. Thus, the Alternative-sensitive view predicts the rate of 'True' responses to be lower in the Condition (d) than in the other three conditions.

(18) E_1: Mary told John about her child.
E_2: Girls rarely join a baseball team.

3.4 Procedure

Participants were randomly assigned one of the four lists of items. For each item, participants were asked to read the scenario carefully, and then to tell us whether the following sentences were either true or false under this scenario by clicking on one of two boxes labeled 'True' and 'False' respectively. Before testing, participants had

6 Nonetheless, we might expect participants to exhibit a greater difficulty in understanding Disjunctive than Non-disjunctive sentences. This is because disjunctive sentences are more complex regarding their grammatical structures as well as their felicity conditions. However, we notice that such an effect of the disjunction should not impact responses to Disjunctive sentences differently across scenarios. Hence, any reliable decrease in the rate of 'True' responses between Condition (c) and (d) would be inconsistent with the predictions made by the Situation-semantic view.

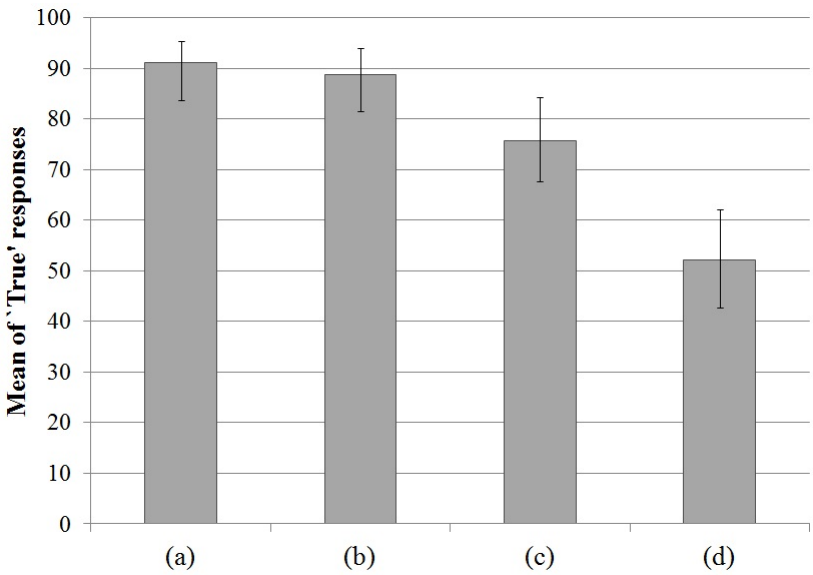

Figure 1 Mean (in %) of 'True' responses to target *know*-sentences as a function of Condition. Error bars are 95% confidence intervals estimated from binomial distributions.

to read a consent statement and fill out a demographic questionnaire.

3.5 Results

3.5.1 Comprehension sentences

Responses to comprehension sentences were aggregated to calculate participants' global accuracy (i.e., 'raw score' for expected true sentences, and '100 - raw score' for expected false sentences). Participants' performance was accurate ($M = 93\%$, $CI_{95\%}$ [91.5, 95.5]) with no difference between true and false comprehension sentences ($t(100) = .79,\ p = .42$). These results ensure that participants did not encounter problems in understanding the scenarios in general, and more particularly in identifying the main characters' beliefs.

Data from 2 participants whose performance in comprehension sentences were not different from chance (accuracy $< 62\%$) were excluded from subsequent analyses (about 2% of the responses). We noticed, however, that including these participants yielded the same pattern of results as the one reported below.

3.5.2 Target sentences

Results to target sentences are depicted in Figure 1. Data were fitted into a mixed-effects linear regression model (binomial family) predicting responses from Scenario (Gettier-Like *vs.* Non-Gettier) and Sentence (Disjunctive *vs.* Non-disjunctive). The model included Subject and Item as random effects, and random slopes for the interaction of Scenario and Sentence grouped by Item. There was a main effect of Scenario, a main effect of Sentence and a significant interaction between these two factors (Scenario: $\beta = -0.82,\ z = -2.89,\ p < .005$, Sentence: $\beta = -1.7,\ z = -6,\ p < .0001$, Scenario×Sentence: $\beta = -1.19,\ z = -2.1,\ p < .05$). *Post-hoc* analyses of the interaction between Scenario and Sentence were performed using multiple comparisons of means for general linear hypotheses (Tukey contrasts). They revealed that the interaction was driven by responses to Disjunctive sentences in Gettier-like scenarios: the rate of 'True' responses was significantly lower in Condition (d) ($M = 52\%$, $\text{CI}_{95\%}$ [42, 62]) than in the other three conditions (all Ms $> 76\%$; all βs < -0.32, zs < -5.81, adjusted ps $< .001$). None of the other comparisons reached significance.

3.5.3 Discussion

The present results make two contributions. First, the present results show that Disjunctive *know*-sentences were in general less frequently accepted than their Non-disjunctive counterparts regardless of the type of Scenarios they were paired with. This overall effect of Sentence can be partly accounted for in terms of the felicity conditions of the disjunction itself. In particular, the difference in the ratings of 'True' responses between the (Non-Gettier) Condition (a) and (c) can be explained by the fact that sentences of the form *x knows that p or q* are infelicitous since a shorter alternative of the form *s knows that p* is true. Second, factoring out the effect of the disjunction, our original contribution is to show that Disjunctive *know*-sentences are less frequently judged as true than equivalent Non-disjunctive sentences under Gettier-Like scenarios. This pattern of results is fully explained if we assume that Disjunctive *know*-sentences are ambiguous in Gettier-Like scenarios (i.e., depending on the piece of evidence), unlike Non-disjunctive *know*-sentences, and that the acceptability of both response types is responsible for the intermediate rating of 'True' responses we observed in Condition (d).

While these findings provide support *a priori* to the Alternative-sensitive view, they could receive an alternative interpretation compatible with the Situation-semantic view. Specifically, the present results could be interpreted as reflecting an ambiguity between a wide-scope reading and a narrow-scope reading of the disjunction operator that would be false and true respectively under Gettier-like scenarios.

In order to test this alternative explanation, we carried out a second experiment.

4 Experiment 2

Experiment 2 is a follow-up study to Experiment 1. Focusing on the interpretation of disjunctive sentences, it aimed at determining whether the pattern of results previously observed in Gettier-Like scenarios has to be attributed to an extra 'false' reading with *know* taking scope over the disjunction, as predicted by the Alternative-sensitive view, or rather to a scope ambiguity of the disjunction operator itself.

4.1 Participants

60 new participants (33 female, aged 19-62, mean = 32 yrs, standard deviation = 10 yrs) were recruited using Amazon Mechanical Turk. Demographics were similar to Experiment 1. Repeat participants were screened out in the same fashion.

4.2 Experimental design

The experimental method used in Experiment 2 was the same as Experiment 1. Scenarios and comprehension sentences were the same as previously described (cf. (15) and (16)). New target sentences were constructed as follows. First, the disjunctive *know*-sentences used in Experiment 1 (cf. (17a)) were modified in order to rule out potential wide-scope disjunction readings, as shown in (19). Again, these sentences were presented with Non-Gettier and Gettier-Like scenarios, giving rise to the Condition (c') and (d') respectively.

(19) John knows the following: Mary has a son or a daughter.

a. John knows that Mary has a son or a daughter. (Narrow-scope)

b. John knows that Mary has a son or John knows that Mary has a daughter. (Wide-scope)

Second, parallel *believe*-sentences, e.g. (20), were added to control for the impossibility of wide-scope disjunction readings in this new linguistic environment. These sentences were constructed so that they were false under a narrow-scope reading of the disjunction when presented with Gettier-Like scenarios (but otherwise true). We will refer to these additional control cases as the Condition Believe.

(20) John does not believe the following: Mary has a son or a daughter.

a. John does not believe that Mary has a son or a daughter. (Narrow-scope)

b. John does not believe that Mary has a son or John does not believe that Mary has a daughter. (Wide-scope)

The predictions made by the Situation-semantic and the Alternative-sensitive views are summarized in Table 2. The procedure was the same as in Experiment 1 (see 3.4).

Condition	Gettier-Like	Disjunction	Predicted response	
			Sit-semantic	Alt-based
(c')	No	Yes	True	True
(d')	Yes	Yes	True	True/False
Believe	Yes	Yes	False	False

Table 2 Summary of the predictions made by the Situation-semantic (Sit-semantic) and the Alternative-sensitive (Alt-based) views as a function of experimental condition.

4.3 Results

4.3.1 Comprehension sentences

Responses to comprehension sentences were treated as in Experiment 1. Participants' global accuracy was very high ($M = 92\%$, $\text{CI}_{95\%}$ [89, 94.5]) with no difference between true and false comprehension sentences. In subsequent analyses, data were excluded from 2 participants whose performance were not different from chance (accuracy $< 62\%$). Including these participants yielded no significant differences in the pattern of results.

4.3.2 Target sentences

Results to target sentences are depicted in Figure 1. Comparisons of responses between the three conditions were carried out using mixed-effects linear regression models (binomial family). Each model included Condition as a fixed-effect and random effects for Subject and Item, with a random slope for Condition by Item.

As expected, the highest rate of 'True' responses was observed in the (c')-condition ($M = 89\%$, $\text{CI}_{95\%}$ [78, 95]), and the lowest rate in the Believe-condition ($M = 17\%$, $\text{CI}_{95\%}$ [9, 29]).[7] The mean rating of 'True' responses in the (d')-condition ($M = 58\%$, $\text{CI}_{95\%}$ [45, 70]) fell between the rating obtained in the (c')-condition and in the Believe-condition: $\beta = 1.81,\ z = 3.57,\ p < .0005$ and $\beta = -1.91,\ z = -4.3,\ p < .0001$, respectively.

7 No difference in participants' accuracy to these two conditions (i.e., 'True' responses in the (c')-condition and 'False' responses in the Believe-condition) was found ($\beta = .59,\ z = 1.06,\ p = .28$).

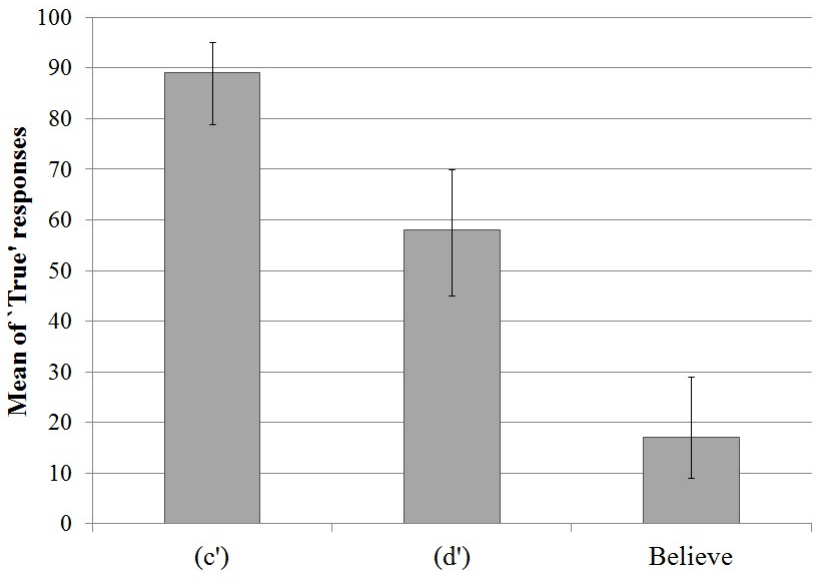

Figure 2 Mean (in %) of 'True' responses to target sentences as a function of Condition. All differences between successive bars are significant. Error bars are 95% confidence intervals estimated from binomial distributions.

4.4 Discussion

These findings replicate the main results from Experiment 1. The rating of 'True' responses in the (d')-condition was found to be similar to that observed for the (d)-condition in Experiment 1, and to fall between the ratings obtained for parallel but unambiguous true and false sentences. Hence, the present results confirm that participants' linguistic judgments of disjunctive knowledge sentences in Gettier-Like scenarios cannot be attributed to a scope ambiguity of the disjunction.

5 Conclusion

In this paper, we discussed the difference in predictions between Uegaki's (2012) alternative-based analysis and non-alternative-based analyses, in particular, Kratzer's (2002) situation-semantic analysis of the verb *know*. These predictions were empirically tested in two experiments using a truth-value judgment paradigm. According to the present results, knowledge sentences with a disjunctive complement are less likely to be judged as true than equivalent sentences without disjunction under Gettier-like scenarios. These findings provide evidence for the alternative-based analysis of *know*, while they call for further explanation in a non-alternative-based analysis.

Nonetheless, open questions remain regarding the generality of these findings. Here, we would like to point out two of them. The first one concerns the precise characterization of alternative-inducing expressions. In this paper, we have focused on a rather simple contrast between disjunctive and non-disjunctive sentences in their alternative-semantic values. However, it remains to be seen whether the current results can be replicated with other alternative-inducing expressions, such as indefinites, when they are paired with suitable classically equivalent examples without an alternative-inducing expression.

The second question is whether the results can be replicated with simpler scenarios that involve just one piece of 'evidence'. The experiments presented in this paper involve scenarios with two independent pieces of evidence, one of which justifies a true proposition while the two pieces taken together lead to a false proposition. On the other hand, in the standard Gettier cases, the agent only has one piece of evidence leading him to believe a false proposition, from which he infers a true proposition. Testing whether the result can be replicated using this kind of simpler scenarios will be our next step.

That said, the findings reported in this paper uncover a previously untested aspect of the semantics of knowledge-attribution sentences, i.e., its alternative-sensitivity. On the theoretical side, this result could be connected to Contrastivism (Schaffer 2007) in the epistemological literature, which tries to understand knowledge in terms of the role of contrasts between alternative possibilities. On the empirical side, this result further enriches the growing literature on the empirical investigation of people's judgment of knowledge attribution (e.g., Weinberg, Nichols & Stich 2001; Starmans & Friedman 2012).

A Stories used in Experiment 1 and 2

(21) **Story 1.** Simon is flying to Europe with his colleague, Mike. Simon's seat is right behind Mike's seat. When the flight attendant came to serve food, he told them that the choices for the dish were either beef or pasta. Simon couldn't hear what Mike ordered, but he is sure that Mike ordered beef because he knows that Mike likes beef a lot. Also, he thinks he can smell beef coming from the row in front of him.

(22) **Story 2.** John is the coach of a little league baseball team. Today, John heard from Mary, one of his neighbors, that she wants her child to be on his team. John didn't know that Mary had a child until then, but he is sure that her child is a boy since all of the kids on his team are boys, and girls rarely join a baseball team. He is not certain if Mary also has a daughter or not.

(23) **Story 3.** George is meeting Lisa at a restaurant. When she enters the restaurant, he notices that she has a pass in her hand that can be used either

for riding the bus or the subway. This indicates that she has used public transportation to come to the restaurant. George is sure that she used the subway because he knows that the subway is more convenient than the bus for her to travel from her house to the restaurant (and the town has no public transportation other than the bus and the subway).

(24) **Story 4.** Kim knows a lot about computers. Today, one of her friends, Sam, asked her to look at his computer because his computer was suddenly very slow. Kim has seen him using a laptop computer. So, she is certain that Sam owns a laptop computer, and that this computer is the one that he wants her to look at. She is not certain whether he also has a desktop computer in addition to the laptop computer.

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